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HIBISCUS FIBER CARBON FOR FUEL CELL DEVICE MATERIALS

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ABSTRACT

HIBISCUS FIBER CARBON FOR FUEL CELL DEVICE MATERIAL. The objective of this research is carbon of hibiscus fibers for the application as basic material of fuel cell device. The carbon is made using a pyrolysis process in inert gas (nitrogen) for 1 hour at temperature of 500 °C, 700 °C and 900 °C. The X-Ray Diffractometer (XRD), Scanning Electron Microscope (SEM) and Impedance-Capacitance-Resistance-meter are used to find out the microstructure, morphology and electrical properties respectively. The results of the experiment showed that the carbon had a structure of amorphous, and as the semiconductor material the electrical conductivity was 5 x 10^{-5} S.cm^{-1} to 4.9 x 10^{-5} S.cm^{-1} increasing in accordance with the pyrolisis temperature. The morphology resembled to plaited mats constructed by porous fibers having width of 50 μm to 300 μm, thickness of 25 μm to 35 μm, and the porous size of 0.5 μm to 5 μm. This morphology enables carbon to be applied as a candidate for a basic material of the Proton Exchange Membrane Fuel Cell.

Key words : Carbon, Hibiscus fiber, Pyrolysis, Electrical conductivity

ABSTRAK

KARBON DARI SERAT *HIBISCUS* UNTUK BAHAN *FUEL CELL DEVICE*. Tujuan dari penelitian ini adalah pemanfaatan karbon dari serat hibiscus untuk aplikasi sebagai bahan dasar *fuel cell device*. Karbon tersebut dibuat dengan proses pirolisis dalam gas mulia (nitrogen) selama 1 jam pada suhu 500 °C, 700 °C dan 900 °C. Difraktometer sinar-X, *Scanning Electron Microscope* dan spektroskop impedansi digunakan untuk mendapatkan mikrostruktur, morfologi, dan sifat kelistrikan bahan. Hasil percobaan menunjukkan bahwa karbon tersebut memiliki struktur amorfas, dan selaku bahan semikonduktor menunjukkan konduktivitas elektrik sebesar 5 x 10^{-5}S.cm^{-1} hingga 4,9 x 10^{-5}S.cm^{-1} dan meningkat seiring dengan suhu pirolisis. Morfologi karbon menyerupai karpet serabut yang tersusun atas serat berporos dengan lebar 50 μm hingga 300 μm, tebal 25 μm hingga 35 μm dan ukuran poros 0,5 μm hingga 5,0 μm. Morfologi tersebut memungkinkan untuk aplikasi sebagai kandidat bahan dasar pada *fuel cell* membran penukar ion.

Kata kunci : Karbon, Serat Hibiscus, Pirolisis, Konduktifitas elektrik

INTRODUCTION

There are various carbon material applications, depending on the physical characteristic and the electric properties, including for the use of an absorber, an electrode of energy device, a conductive material, reinforced plastics, reinforced concrete and structural composites. Carbon is electrode basic material of Proton Exchange Membrane Fuel Cell (PEMFC). Requirements for materials and components for PEMFC electrodes: capable of forming triple point conditions (interface/ meeting electrolyte cathode space/cavity/pore), as the scene of the electrochemical reaction; may distribute oxidant, electron conductor and able to drain the water and heat [1]. Components form the framework of the porous electrode. Therefore, the electrode components should accomplish the requirements which are: a high electron conductivity, heat resistant (80-100 °C), has a surface area (high porosity 40-80 %) containing a catalyst, stable in operating conditions, enough light, mechanically strong and corrosion resistance [2].

Based on the value of its electrical conductivity material can be divided into conductors, semiconductors and insulators. Figure 1 shows the conductivity for

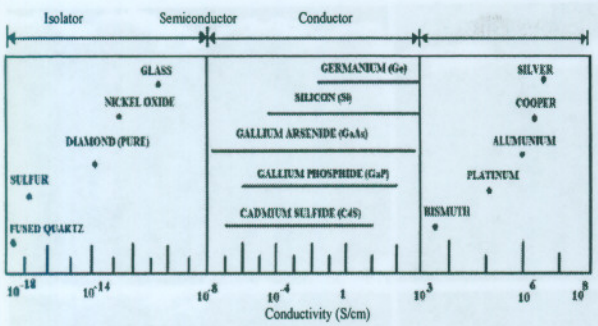

Figure 1. The various materials based on electrical conductivity [6].

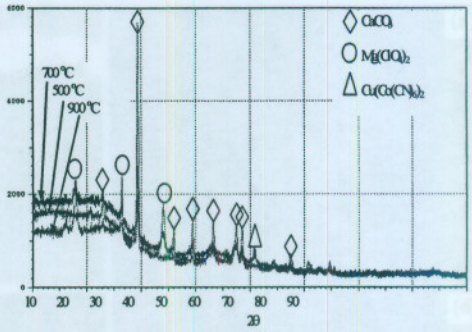

Figure 2. The X-Ray diffraction pattern of the charcoal of hibiscus fiber

insulating material is in the interval of 10^{-18} S.m^{-1} to 10^{-8} S.m^{-1}, semiconductor located within an interval of 10^{-8} S.m^{-1} to 10^{3} S.m^{-1} and the conductor is in the interval value of 10^{3} S.m^{-1} to 10^{8} S.m^{-1} [6].

The physical and structural characteristics of carbon or charcoals have been studied. Such studies indicate that the manufacturing temperatures significantly affected the physical properties of charcoals, such as mass loss, dimensional change, sorption, density, specific area, porosity and electrical conductivity. Charcoals morphology of quercus variabilis have been also observed [3], as well as the charcoals morphology of oil palm fiber and coconut fiber, prepared in an electric furnace under nitrogen gas atmosphere each until 900 °C, by scanning electron microscopy [4,5].

Hibiscus is being tropical plants, mainly grown on the coast that is not swampy or near the coast. Hibiscus grow wild in forests and in fields, sometimes planted in the yard or by the roadside as a shade tree. In Indonesia, the plant is called *waru*.

The community, using leaves for medical and vegetable. The bark, after being soaked and pounded will result in fibers. This fiber is very good to be a rope. The purpose of this research to study the morphology of hibiscus fibers carbon and studied its electrical conductivity at different pyrolysis temperature.

EXPERIMENTAL METHOD

The hibicus fibers carbon made using a pyrolisis method in inert gas (N_2). The pyrolisis process is carried out at the temperature of 500 °C, 700 °C and 900 °C and it is held for 2 hours, following the pyrolisis process of the other natural fiber [4,5]. Analysis of the charcoal is performed to determine the content of elements using EDS (Energy Dispersive X-Ray Spectroscopy), the structure using an XRD (X-Ray Diffractometer, PW 1070), electrical conductivity using LCR-meter HIOKI 3522-50 HITESTER and the morphology by SEM (Scanning Electron Microscope, JEOL JSM-6390 Series).

RESULTS AND DISCUSSION

According to EDS analysis, the main element of charcoal is carbon. Figure 2 shows the X-Ray diffraction pattern of the charcoal of hibiscus fiber. In the figure there are two types of peak i.e. sharp peak and the hill with the slight slope. The hill indicates that the carbon has amorphous structures. The sharp peak indicates that the charcoal of hibiscus fiber has other crystal structure. Based on the results of search and match using the data from the Powder Diffraction File, the peaks showed the existence of the mineral containing within hibiscus fibers. The peaks indicates $CaCO_3$ (JCPDS No.5-586), $Mg(ClO_4)_2$ (JCPDS No.1-629) and $Cu(Co(CN)_6)_2$.

Figure 3 shows the electrical conductivity of hibiscus fiber carbon that was measured using LCR meter. The Figure shows that the electrical conductivity were 5 x 10^{-5} S.m^{-1} to 4.9 x 10^{-5} S.m^{-1} and increasing with the increasing of pyrolysis temperature. In this case the carbon is classified as the semiconductor materials.

Figure 4(a), Figure 4(b) and Figure 4(c) show the morphology of hibiscus carbon surface, the cross section, and enlarge of the cross section images, respectively. The morphology resembled to plaited mats constructed by porous fibers having width of 50 μm to 300 μm, thickness of 25 μm to 35 μm, and the porous size of 0.5 μm to 5 μm. According to this morphology, the carbon of hibiscus fiber is suitable for the basic material of the PEMFC electrode. Nevertheless, the electrical properties of the carbon should be investigated to

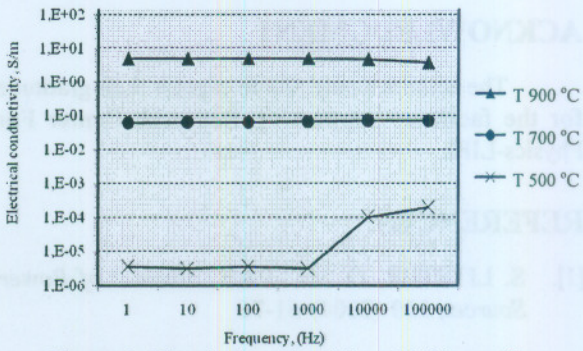

Figure 3. Electrical conductivity of hibiscus fiber carbon at different frequency

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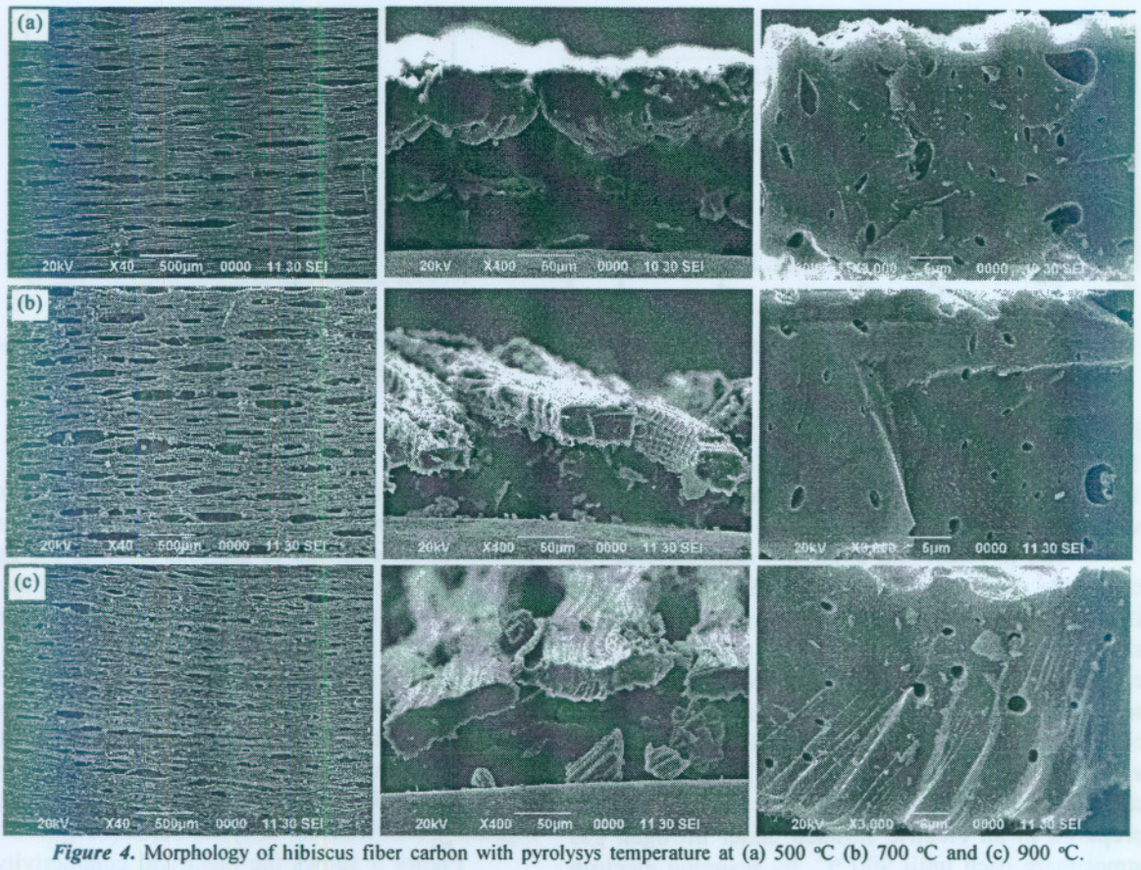

Figure 4. Morphology of hibiscus fiber carbon with pyrolysys temperature at (a) 500 °C (b) 700 °C and (c) 900 °C.

accomplish the necessary properties as basic material of PEMFC electrode.

CONCLUSION

The result of the experiment shows that the hibiscus fiber carbon has a structure of amorphous, and carbon is classified as semiconductor materials. The electrical conductivity increase in accordance with the rising of pyrolisis temperature. The morphology resemble to plaited mats constructed by porous fibers. The morphology enables this materials to be applied as a candidate for a basic materials of the PEMFC but the conductivity should be increased.

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